ANALYSIS OF ROCKS.

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ANALYSIS OF ROCKS.

How to interpret the composition of rocks has been a question which has caused a great deal of discussion and investigation among geologists and chemists. It is evident that that analysis will give the clearest results, which will give the relative proportion of the different minerals composing the rock as well as the weight of their different constituents. This, however, is a very difficult matter, and in those rocks which seem to the naked eye entirely compact, like obsidian and other rocks of that class, appears to be impossible.

Cordier, in the early part of the century, invented a process which is known as the "mechanical analysis of rocks," which is really a method of mechanical preparation, and consists in crushing the rock to a certain fineness, and then, by virtue of their density, washing out the different minerals, so as to make a mineralogical analysis, separating completely the different constituents of the rocks. In the hands of so skilful a man, this was a comparatively easy matter, and Cordier found no difficulty in ascertaining the mineralogical composition of a rock. The ultimate chemical composition was ascertained from the sum of the elements contained in the different materials.

In the light of to-day, it is very easy to see that the complete chemical analysis of the rock does not necessarily lead to the explanation of its character. It has been so difficult, however, to have any other kind of analysis made that most chemical examinations have been made as ultimate, and not as mineralogical analyses. The panning out of the different minerals composing the rock, which are often very nearly of the same specific gravity, is so difficult that a person of ordinary mechanical skill is scarcely able to do it; consequently the mechanical analysis which Cordier proposed, and was able himself so skilfully to effect, has never been practiced to any extent. A school was formed in France consisting of a very small number of Cordier's followers, which, in face of the difficulty of

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acquiring the method, very soon died out as a school, though some of his most skilful followers are still living.

The next important step in ascertaining their composition was to cut the rock into transparent sections and examine the minerals with the microscope, which gave results more or less certain.* The adaptation of polarized light to the study of these thin sections was almost of necessity the next step in order, and was for a very long time supposed to be almost the *ultima thule* of lithological investigation. Notwithstanding, however, the great hopes which were entertained, and the thousands of sections which have been cut and investigated, less has been derived from their investigations than was at first hoped. The machinery which is required for cutting and grinding the surfaces necessary for examination for micro-analysis by polarized light is expensive, and the skill required, and the time necessarily consumed, are such that few feel warranted in undertaking the method, though the difficulty is more in imagination than reality. The lithologists are still looking for some method of investigation which shall be as certain and less difficult of accomplishment.

In 1873, while studying micro-lithology, I had the good fortune to make the acquaintance of Mr. Fouqué, of the College of France, who had been studying for some years the volcanic rocks of Santorin, and who, finding all the known methods for examining these rocks unsatisfactory, had invented one of his own, which is within the reach of every chemist or lithologist, and with a few additions taken from other methods, is of general application. After making a careful microscopic analysis of the rocks of that country, and ascertaining that although nearly compact, they were composed of a large number of minerals,† and that these microscopic minerals, like most of those which are larger, are rarely ever pure, but are filled with inclusions, both solid, liquid, and gaseous, Mr. Fouqué invented a process which is partly mechanical and partly chemical. It consists (1), in reducing the rock to powder and separating, by means of graduated sieves, the coarse parts from the fine powder. (2.) In order then to separate those parts which contain iron from those which do not, the powder is submitted to the action of an electromagnet, worked by eight or nine ordinary Bunsen cells. The mineralogical elements of the rock are thus divided into two parts: those which contain iron, even in very small proportions, whether combined with silica or not, and those which contain no iron. The white powder, in ordinary cases, is composed almost entirely of feldspathic minerals, which, when there are several varieties, may be separated either by differences in their size, for they are rarely ever crystallized in the same way, or by the fact of their being unequally acted upon by acids. In order to ascertain the composition of the other part of the rock, Mr. Fouqué uses concentrated fluohydric acid, which, when the temperature is not raised, and the action not too prolonged, attacks the feldspars only, and leaves behind such minerals as magnetite, pyroxene, and chrysolite. Magnetic iron is easily removed by the magnet, and pyroxene and chrysolite may be separated by their color with a magnifying glass, or attacked by a weak solution of sulphuric acid, which acts upon the chrysolite and does not act upon the pyroxene. By the application of this exceedingly simple method, Mr. Fouqué was able to determine eight different minerals in a rock which is either black and compact or else granular, in which last case it is possible to distinguish the minerals with the eye, and to separate them, so that it was possible to make a complete analysis of each of them. The use of a low-power microscope is indispensable in these operations, both to see that the crystals with small inclusions have been removed, and also to watch the effect of the different acids.

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* Some observer has proposed to make a drawing of the enlarged section on a thin sheet of paper, and then to cut the outlines of the different minerals apart and weigh them, and thus ascertain the relative proportion of the different minerals. It is said that quite accurate results are obtained in this way.

† The rock resembles obsidian with small whitish crystals scattered through it.

The first operation consists in reducing to powder two or more kilogrammes of the rock and sifting them so that all the grains shall be of a uniform size and about a quarter of a millimetre in diameter. This powder is divided into two parts, which are to be treated differently. The first of these is submitted to the electro-magnet, which, for convenience, is suspended by a wire to within three or four centimetres of a table. The material to be acted upon is placed upon a sheet of paper which is raised in the two hands and moved close under the magnet. One of the ends of the wire is so arranged as to fit the clamp-screw without the necessity of being clamped. After the paper has been moved several times underneath the magnet it is withdrawn from it and placed to one side of the table. Another paper is now brought under the magnet, and the wire, which is not clamped, removed. All the material containing iron, of whatever form it may be, that has been attached to the magnet, falls to the paper. The wire is then replaced, and this process is repeated a number of times until the microscope shows that all the powder that remains on the first paper is free from any coloring matter and entirely white. This operation requires a great deal of patience and care, because there are, in different feldspars, very small inclusions, which are not easily taken up, but which must be removed. All the material containing any considerable percentage of iron, whether a silicate or not, is removed in the first two or three passes, and then it requires a careful observation with the glass to ascertain, after fifteen or twenty passes, whether there is anything which should still be eliminated from the mass. It required thirty to forty passes under the magnet to remove all the material containing iron from a somewhat decomposed basalt rock of New Hampshire. The white residue which is left, is composed almost entirely of feldspar, and generally the grains of either species will be of different sizes, and often will be either crystals or crystalline in form. On submitting these feldspathic grains to the action of moderately strong muriatic acid they are either attacked or not attacked. Those which are not attacked will be orthoclase, albite, and labradorite, and those which are will be generally anorthite. The second part of the powder is acted upon by fluohydric acid, which, when its action is not too long, nor the temperature too high, dissolves at once the feldspars and amorphous matter of the rock, and leaves behind a crystalline residue composed of such minerals as pyroxene, chrysolite, and magnetite. The magnet takes out the magnetite, and the chrysolite and pyroxene may be separated with a glass by their difference in color, or by their different solubility in acids.

In this way sufficient material was collected to make analyses of all the different minerals of a rock appaeently compact, namely, two kinds of pyroxene and chrysolite, magnetite, albite, anorthite, and labradorite. Mr. Fouqué communicated these results to the Academy of Sciences in May and June, 1873. To complete this work, the rock was cut into sections and photographed, and for this particular work Mr. Fouqué had become so skilful that he was able in the photograph to point out each variety of the different minerals and to control his determination by the analysis that had been previously made. He found in his observations, that all the different feldspars in the rocks in Santorin were in crystals of different dimensions, and that they could be easily recognized by their structure alone, after studying the rock.

On examining these slides made from the rocks by polarized light, by the methods proposed by Tschermack, Rosenbuch, and others, the crystals were determined in the rock. After working for some time upon the rocks of New Hampshire, and using them both as sections and with the method of Mr. Fouqué, it occurred to me that it was not always necessary to cut sections, but that a simple examination of the powder before passing under the magnet would be quite sufficient. I found it quite difficult to prepare these slides, but, finally, adopted the plan of using a few drops of a very thin solution of Canada balsam in chloroform, placed upon a microscope cover-glass, upon which a sufficient quantity of powder was afterwards placed. With a glass maynifying five or six diameters, it was easy with a needle-point to separate all the different grains, and then by evaporation to have them all kept in their place by the small quantity of Canada balsam. This cover-glass was afterwards turned down upon a drop of Canada balsam, and in this way I succeeded in mounting a large number of slides which answered all the purpose of sections.

Mr. Fouqué's method must be considered as an important step in the progress of lithology. One of its greatest advantages is, that it furnishes for analysis very small crystals, which are always purer than large ones, and are much less likely to contain inclusions. It is, besides, a method which any person possessed with a moderate amount of patience can readily learn, and with a few variations it is applicable to all varieties of crystalline rocks.

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